Current Usage and Future Prospects of Multispectral (RGB) Satellite Imagery in Support of NWS Forecast Offices and National Centers

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What is an RGB Composite Image?

- Current and future satellite instruments provide remote sensing at a variety of wavelengths.
- RGB composite imagery assign individual wavelengths or channel differences to the intensities of the red, green, and blue components of a pixel color.
- Each red, green, and blue color intensity is related to physical properties within the final composite image.
- Final color assignments are therefore related to the characteristics of image pixels.
- Products may simplify the interpretation of data from multiple bands by displaying information in a single image.

Current Products and Usage

- Collaborations between SPoRT, CIRA, and NRL have facilitated the use and evaluation of RGB products at a variety of NWS forecast offices and National Centers.
- **Table 1** provides a list of RGB products that have been developed by these groups and disseminated to end users for a variety of applications.

Product	Instruments	Purpose
Air Mass	SEVIRI, MODIS GOES Sounder	Discriminate between air mass types
Dust	SEVIRI, MODIS, VIIRS	Identify blowing or suspended dust
Fog and Low Clouds	SEVIRI, MODIS, VIIRS	Identify fog and low clouds
Natural Color	SEVIRI, MODIS, VIIRS	Approximates a true color image
True Color	MODIS, VIIRS	True color, photograph image
False Color Snow	MODIS, VIIRS	Discriminates clouds from snow
Passive Microwave	DMSP via SSMI and SSMI/S TRMM	Tropical cyclone characteristics Midlatitude cyclones and precipitation
Day-Night Band	DMSP and VIIRS	Visible (moonlit) imagery provides cloud texture and city lights

Table 1. Brief list of RGB satellite products evaluated within the operational forecasting environment, the instruments currently used in their production, and likely applications.

- Forecasters provide feedback to product developers at SPoRT, CIRA, and NRL through a variety of interactions. For example, SPoRT has established targeted evaluation periods with partnering forecast offices to acquire feedback that relates to product tuning or display characteristics within AWIPS.
- Other assessment activities have included GOES-R and JPSS Proving Ground interactions at NWS National Centers (**Figure 1**).
- Products are used within operations and occasionally cited within Area Forecast Discussions or other publically released products.

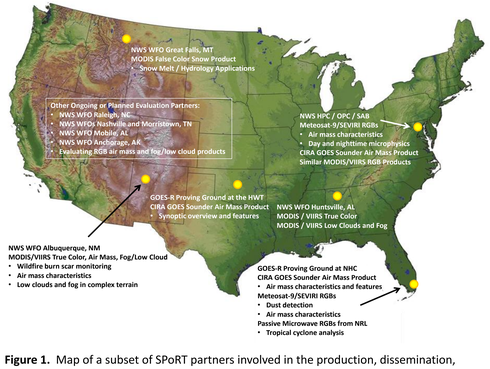

Figure 1. Map of a subset of SPoRT partners involved in the production, dissemination, and evaluation of multispectral satellite products in weather forecasting operations. Several other offices (not shown) participate in product evaluations with CIMSS and CIRA.

Product Examples and Usage

- Several product are being disseminated for test and evaluation by NOAA/NWS field offices and National Centers as part of NOAA's GOES-R and Joint Polar Satellite System (JPSS) Proving Grounds.
- SPoRT has partnered with the Naval Research Laboratory in Monterrey, CA to transition popular passive microwave composites to N-AWIPS for use at the National Hurricane Center and the Hydrometeorological Prediction Center.

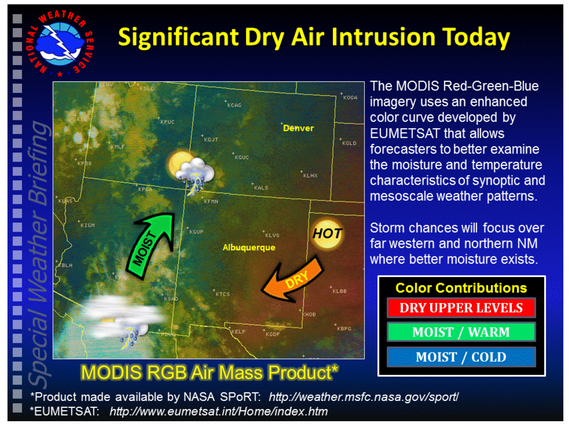

Figure 2. Example of the MODIS RGB Air Mass Product used to identify hot, dry air associated with a long-term heat wave over the Southern Plains, versus monsoon flow and moisture into Arizona and New Mexico. Example produced by the National Weather Service forecast office in Albuquerque, NM.

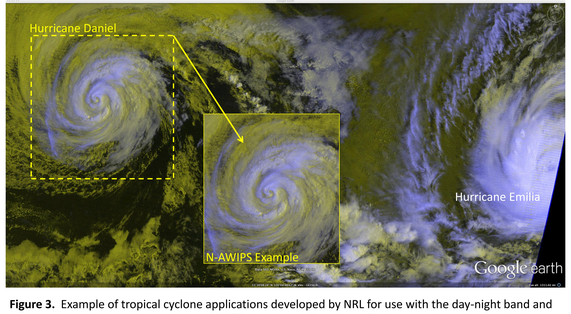

Figure 3. Example of tropical cyclone applications developed by NRL for use with the day-night band and infrared cloud top temperature band of VIIRS. Hurricanes Daniel and Emilia are visible due to reflected moonlight. The inset panel for Daniel provides an example of what the product would look like when colors are quantized for display within the N-AWIPS system used at the National Hurricane Center.

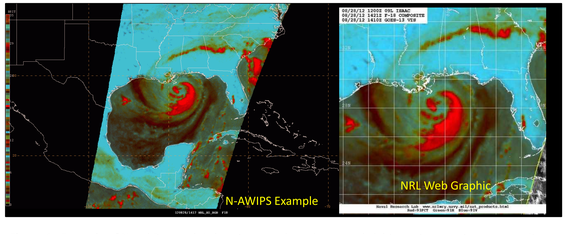

Figure 4. Example of Naval Research Laboratory passive microwave brightness temperature composites provided by NRL and SPoRT via N-AWIPS (left) versus current, popular web graphics (right) for Tropical Storm Isaac prior to landfall near New Orleans, LA. Image acquired at 1421 UTC on August 28, 2012.

- Partnering entities are provided training through SPoRT's forecaster training modules, forecaster "quick guides", conference presentations , discussions with developers at CIMSS or CIRA, and materials developed by the satellite community.
- Feedback is provided through informal discussion or more formalized product surveys, in addition to operational use cases provided through GOES-R and SPoRT partner blog entries.

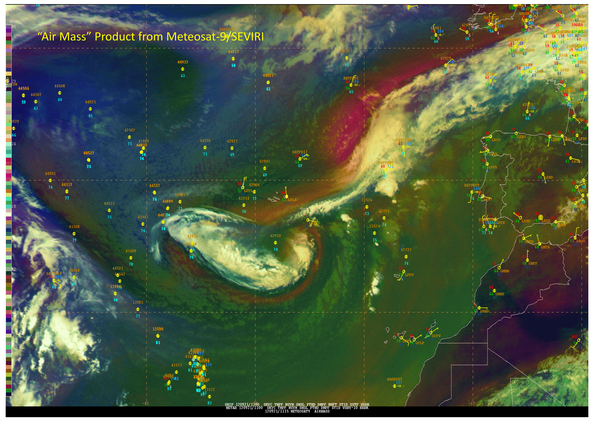

Figure 5. Example of the Meteosat-9/SEVIRI air mass product used to analyze the extratropical transition of Tropical Storm Nadine. Colors emphasize the possible intrusion of dry air and mid and upper levels (reds) near the cyclone in addition to interactions with a midlatitude cyclone to the northeast. Example and analysis provided by Michael Folmer (GOES-R/HPC) and Michael Brennan (NHC) via the GOES-R Proving Ground blog developed for HPC, OPC, and SAB. The Meteosat-9/SEVIRI Air Mass product was originally developed for Google Earth applications by CIRA and transitioned to use in N-AWIPS in collaboration with SPoRT.

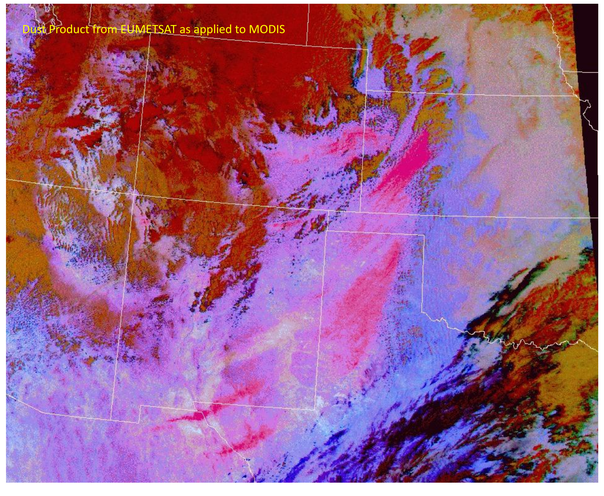

Figure 6. An example of the EUMETSAT "Dust" RGB developed from MODIS channels with application over the southwestern United States. Here, lofted dust areas appear as a vibrant pink, west of a dry line advancing eastward across the Texas Panhandle and portions of southeastern New Mexico. Selected channels enhance the appearance of lofted dust that might otherwise appear hazy in traditional single-channel visible, single-channel infrared, or even true-color RGB imagery.

Future Directions and Opportunities

- The examples provided here demonstrate that multispectral (RGB) composite satellite imagery may offer some new applications using current satellite observations and those expected from future instruments such as GOES-R and JPSS.
- However, current decision support systems such as AWIPS, AWIPS II, and N-AWIPS lack capabilities to display imagery at the full color depth. AWIPS and AWIPS II are currently limited to 254 colors, whereas N-AWIPS is limited to 94 colors. 24-bit imagery assign 8-bit colors to three values, resulting in 256^3 possible colors.
- New capabilities will need to be developed for the AWIPS II environment to support RGB image analysis and manipulation. These capabilities likely include:, but may not be limited to the following:
  - Shader language or other color palette capabilities to display the full 24-bit color resulting from the R, G, B triplet at each pixel.
  - The ability to load pre-defined RGB composites as a "product baseline", in addition to the forecaster or analyst being able to make minor adjustments as needed to enhance specific features.
  - Other image enhancement techniques that are beneficial to single-channel or channel-difference imagery, such as histogram equalization or multiple segments of linear stretching.
  - Opportunities to expand to 32-bit imagery that incorporates an alpha channel or transparency layer to blend quantitative information or cloud textures provided by high resolution visible or infrared data.

Data Dissemination Strategies

- As new satellites are launched and come online, they provide a tremendous increase in data volume distributed to operational centers in addition to continued increases in model output and availability of additional radar products.
- Some, but not all satellite platforms or channels are included as baseline products. Some RGB products may require the inclusion of an additional band , or several bands, that are outside of the baseline.
- In terms of efficient data distribution, there are several options that can be discussed and debated, ranging from dissemination of all required (missing) bands and production of the final product at the forecaster workstation to construction of products by a provider and shipment of a single file. Some options are outlined below.

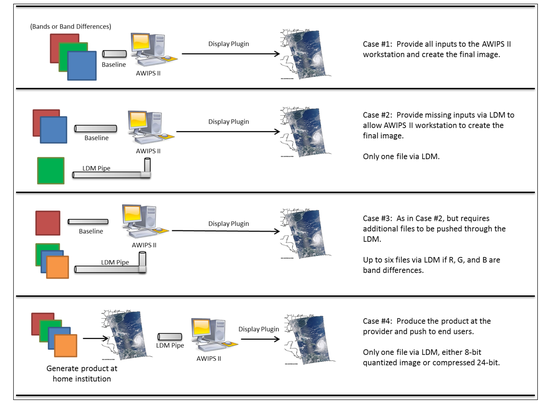

Figure 7. Possible options for disseminating the required inputs for final RGB composite products, ranging from the dissemination of all required bands via the baseline to dissemination of a single, final product generated by the data provider. Each dissemination option offers various strengths and weaknesses that will need to be discussed at a programmatic level among developers and users as these products gain more traction within the operational forecasting environment.